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THE DEVELOPMENT OF A LOW-WORK-FUNCTION COLLECTOR FOR THERMIONIC ENERGY CONVERTERS

Authors:

W. B. Hall
R. J. Hill
J. J. O'Grady

Approved by:

F. G. Block
J. L. Straub, II

RADIO CORPORATION OF AMERICA
Electron Tube Division
Lancaster, Pennsylvania

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THE DEVELOPMENT OF A LOW-WORK-FUNCTION COLLECTOR FOR THERMIONIC ENERGY CONVERTERS

SECTION I

PURPOSE

The effort under the subject program will be directed to the achievement of a "low-work-function collector" for converters operating in the "Ball-of-Fire" mode of the low-voltage arc. Changes in work function will be determined by comparative measurement in actual operation of converters under identically controlled conditions. Three approaches will be investigated: (1) the development of a material or surface which, when partially coated with cesium, gives a low-work-function, (2) the development of a low-work-function surface which is kept free of cesium, and (3) the addition of gas additives which, in conjunction with cesium on the base material, produces a low-work-function.

26 April 1963

SECTION II
DETAILED FACTUAL DATA

A. General

The effort under the subject contract has progressed in accordance with the program outlined in the first report.

B. Detailed Program

The design of all the components has been completed and all parts ordered. Most of the items have been received and fabrication has started.

The feasibility of using a long bellows for a flexible coupling was demonstrated using a mock-up assembly.

The main design problems include the development of an emitter capable of working in the 1200-1400° Centigrade range with stability and reliability and having a low temperature variation across its diameter. It is also important to be able to outgas and "age" the emitter at temperatures higher than 1200-1400° Centigrade operating range, preferably up to 1800° Centigrade. In order to process an emitter for these properties electron bombardment heating and conduction heating are being evaluated. The electron bombardment method is capable of reaching the high outgassing temperature, but may present problems of poor radial temperature distribution. In conjunction with the electron bombardment design, a conduction-heated emitter has been designed and a test model constructed. This conduction-heated emitter consisted of a heater of photoetched 0.002-inch thick, rhenium sheet, sandwiched between two thin sheets of high temperature ceramic. The sandwich was pressed into a recess in the back of the emitter and held in place by a molybdenum disc. Preliminary tests of this design show that at 1450° Centigrade

there is very little variation in temperature across the emitter surface. The top working temperature of this device is limited by the melting point of the ceramic; which is in excess of the 1800° Centigrade level desired.

The first approach, as outlined in Section I of this report, will be the investigation of the physical nature of a collector material and its relation to minimum work function. Collectors will be constructed of single crystal, ultra-pure polycrystalline, and matrix materials. Tungsten has been chosen for the initial test because of its availability in the three desired forms.

In conjunction with this investigation, additional collectors are being fabricated employing the following materials:

(a) Nickel, in pure and commercial grades
(b) Niobium
(c) Tantalum
(d) Molybdenum
(e) Stainless Steel - Type 304
(f) Rhenium
(g) Iridium

as matrix on a molybdenum base

The first test will indicate the optimum material form to be used for best performance. Subsequent tests will determine the best material for use in a collector.

The cesium distillation system has been modified to incorporate a liquid nitrogen cold finger. This modification will achieve an increased purification of the cesium following the method of Herold, [1] by the removal of hydrogen. It will also facilitate electron bombardment outgassing of collectors, and evaporation of material onto collectors, without the complete removal of cesium from the system.

[1] Herold, Annales de Chemie, Ser. 12, 6, 33 (1951).

SECTION III
PROGRAM FOR NEXT REPORT PERIOD

The effort during the next report period will include the following items:

(a) Assembly of parts and completion of the test vehicle.

(b) Evaluation of electron bombardment and directly-heated emitters.

(c) Test of circuit for monitoring characteristic curves as compared with prior experience.

(d) Assembly and check-out of RCA-owned vacuum system.

(e) Development of methods of fabrication of matrix collectors employing rhenium and iridium on a molybdenum base.

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